





# F/A-18E/F BUILT IN TEST (BIT) MATURATION PROCESS

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## Outline



- Background
- False Alarm Impact
- F/A-18E/F BIT Development Process
  - Flight Test Execution
  - Results
  - Fleet Support Efforts
- Conclusions





## Background



## F/A-18C BIT Performance

- Legacy F/A-18 C/D aircraft
  - High false alarm rate > 88%
  - Low mean flight hour between false alarm (MFHBFA) ~1 per flight hour
  - 68% of all organizational level maintenance is driven by BIT.
  - 75% of all cannot duplicate (CND) maintenance is caused by BIT.
- Much of this equipment is common with the F/A-18E/F



#### F/A-18C BIT



## False Alarm Impact

- Needlessly increases maintenance workload
- Decreases aircraft availability/fleet readiness
- Burdens supply system
- Increases cannibalization
- Ties up test benches
- Causes mission aborts
- Reduces pilot and maintainer confidence in aircraft readiness



### F/A-18C



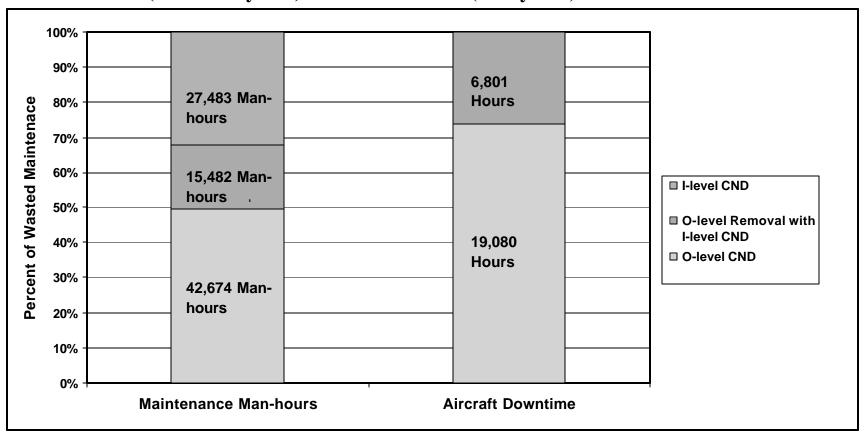
## False Alarm Impact

85,639 Wasted Man-hours

**(46.3 Man-years)** 

**25,881 A/C Down time** 

(2.96 years)







## **Development Process**

- Establish and support realistic design requirements that meet operational goals (MFHBFA)
- Establish design and development processes to achieve acceptable levels of BIT
- Monitor and support system level BIT development and integration
  - Most false alarm problems are found in system level integration testing, not in the lab.
- Periodically report current status





## **Development Process**

- Program management commitment
  - Funding
  - Priority/emphasis on BIT corrective actions
  - Leads to system's engineering commitment
- Dedicated BIT system team committed to mature BIT





## Flight Test Plan for Execution

- Assemble BIT development team
- Assemble knowledgeable maintenance monitor and documentation personnel
- Develop and document a plan
- Establish ground rules
- Develop tools
- Develop reporting criteria



## F/A-18E/F BIT Data Collection



- Aircraft recorded BIT data
- Maintenance data / failure data
- Flight data
- Database / Database analysis programs
- Server/connectivity with all engineering disciplines for subsystem support





## **Data Compilation**

- Correlate BIT indications to maintenance actions
- Coordinate anomalies with proper product team.
  - Document
  - Investigate and characterize to determine root cause
  - Develop, test, implement corrective actions
  - Update database / relevancy and anomaly reports
- Assign relevancy to all BIT indications
  - Fault detect, fault isolate, false alarm
- Weekly BIT Review Boards



# F/A-18E/F BIT Data Analysis



- Current status as related to design and operational requirements
- Predicted growth based on projected (known and forthcoming) corrective actions
- Assessment of each team's performance
- Status of deficiency reports
  - Number of new, open, and recently closed reports
  - Number of reports with known corrective actions.
- Present high drivers



# F/A-18E/F BIT Philosophy



- Fix every anomaly that can be characterized
- Verify reasonable "noise floor level" performance
  - Frequency of false alarm too low to characterize
  - Too hard to fix
- Priority support by product team engineers to analyze and correct deficiencies
- Incorporate diagnostic file filter (DFF) function
  - Legacy equipment problems
  - Integration issues that cannot be corrected with system SCS



### F/A-18E/F BIT



## Team Progress Visibility

- BIT false alarm growth is very slow to start
  - Difficult to characterize every anomaly
  - Hard to create enthusiasm to work BIT and develop fixes
  - Other system problems have priority
  - Software updates infrequent
- Provide team members and program management with visibility of impact(s) and progress
- Always relate to design requirements



# F/A-18E/F BIT Success Story

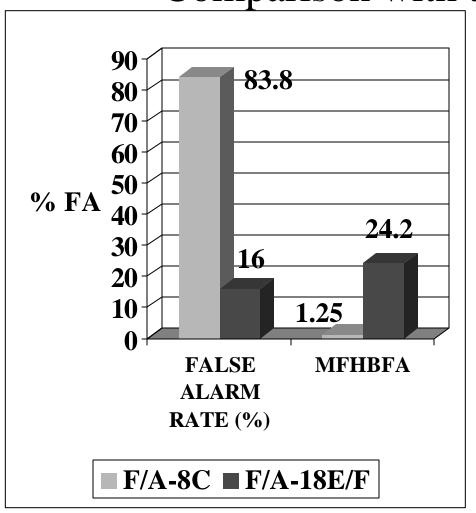


- Although slow to materialize, growth eventually appeared
- Pilots and maintainers as well as system engineers became dependent on BIT
- Met all Operational Requirements Document and Test and Evaluation Master Plan BIT requirements
- The process worked!





## Comparison with the F/A-18C



- C/D BIT No dedicated BIT team during EMD, few fleet BIT improvements incorporated.
- E/F EMD Worked BIT Problems to meet BIT Rqmts.

F/A-18C Data from LOT XIX Eval 7-9/97

(Excludes FLIR)

E/F EMD TECHEVAL data through RMRB 53 (4425 FH)

10-20-2000

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## Fleet Support Efforts

- Post EMD equipment upgrades drive changes to system integration and BIT
- Implement an Air Vehicle BIT Team
  - Manage and coordinate overall F/A-18E/F BIT development, integration, and testing
  - Coordinate fleet issues
  - Maintain dialogue with fleet operators to identify adverse trends
  - Maintain communication with integrated product teams





## Fleet Support Efforts

- Implement BIT Engineering function at the Aircraft Weapons Lab, China Lake, CA
  - Coordinate flight test BIT issues with IPTs.
  - Maintain consolidated list of known BIT deficiencies.
- Conduct aircraft level BIT evaluations during software configuration set verification and validation.





## Fleet Support Efforts

- **Implement Logistics fixes** 
  - Train maintenance personnel to trend BIT indications
  - Implement BIT Training course
  - Develop Maintenance Gray Book
    - Detailed BIT code logic
  - Develop a list of known false alarms.





#### **Process Must Continue**

- Improved readiness
- Improved manpower
- Improved a/c availability
- Improved mission readiness
- Improved mission accomplishment

A more effective war fighter's machine



## Integrated Diagnostics 7 5 4 Maturation

#### Problem

- Driven by technology insertion
- Integration complexity is not understood by management
- Integrated diagnostics maturation is not a funded functional area



# Integrated Diagnostics TEA HORNET Maturation

#### Solution

- Priority platform Program Management support
  - Budget for ID engineering support for the life cycle
  - Provide ID maturation test time (lab and flight)
- Engineering support from all associated functional areas.
  - Identification and correction of ID deficiencies
  - Priority for timely implementation





## Conclusions

- Complex weapon system diagnostics engineering support teams are essential to meeting the Navy's operational and logistic goals.
- Implementation of a totally integrated Navy/Contractor Integrated Diagnostics support team throughout the life cycle of the weapon system is highly effective and provides significant return on investment through lower life cycle costs, improved readiness, safety and mission effectiveness.



## Government Engineering Support Team

- Karen Bain: Lead Engineer, F/A-18 R&M
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- Dave Orwig: Eagle Systems Inc.
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## Back-ups

(Eye /Charts)

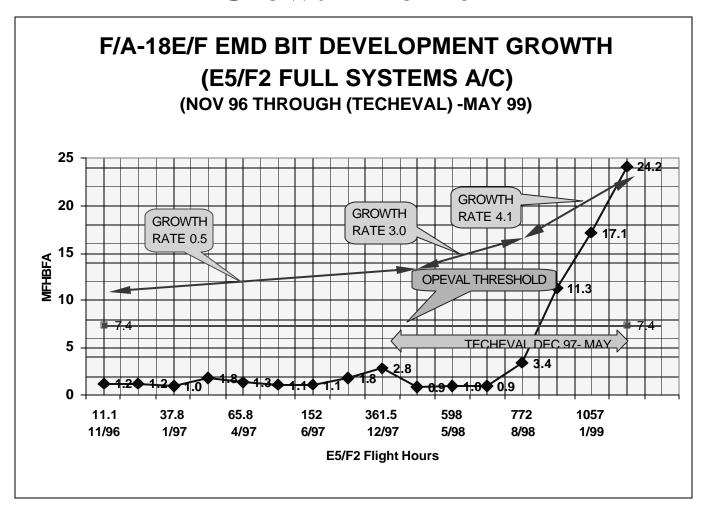
(Eye /Charts)

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#### Growth Profile







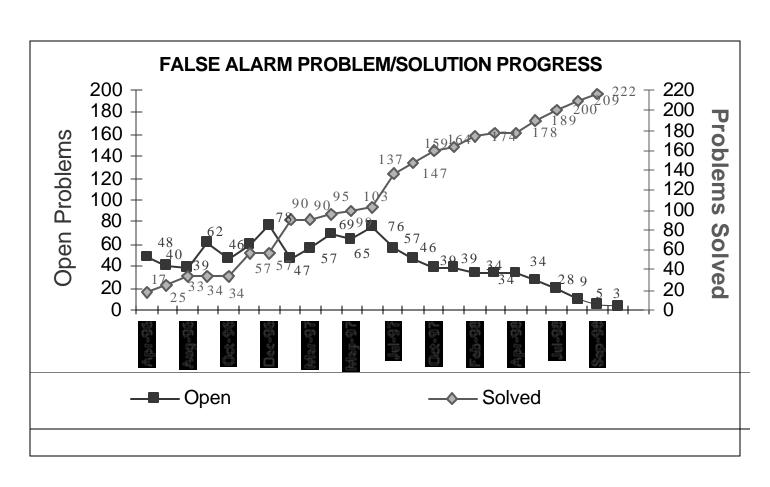
## **Engineering Support**

- 222 problem areas identified and corrected
  - Represented over 5300 false alarms
- Priority implementation by system SCS or diagnostic file filter (DFF)
  - Adequacy of fix confirmed
  - Performance re-evaluated
  - Improvements reported
- Growth observed!!!





### Problems/Solutions





### F/A-18E/F BIT



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#### Performance Results

BIT Parameter	Requirement (Note 1)	TECHEVAL Performance	OPEVAL Performance
Fault Detection %	> 65%	99.0%	94.9%
Fault Isolation %	> 85%	99.5%	91.9%
False Alarm %	< 45%	16.0%	32.3%
MFHBFA (Note 2)	> 7.4 hours	24.1 hours	11.5 hours

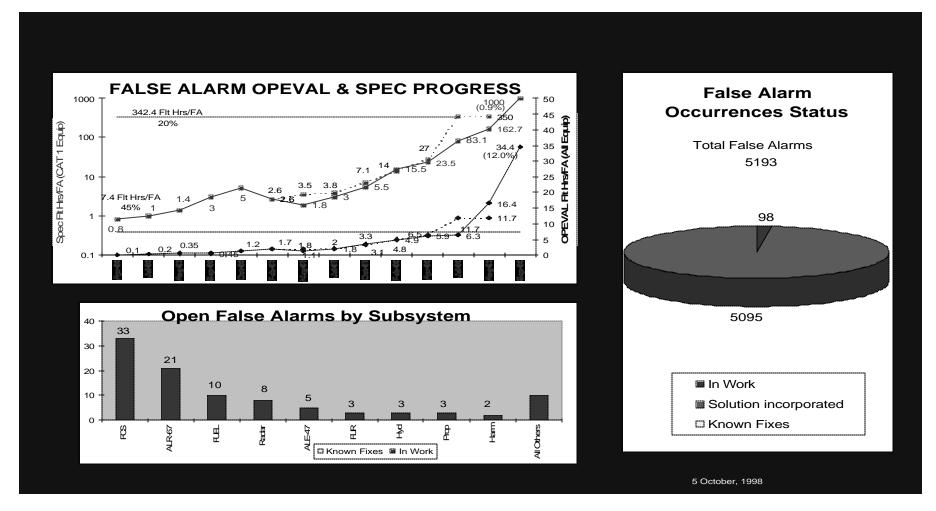
#### Notes:

- 1. Test and Evaluation Master Plan, Minimum Acceptable Operational Performance Requirements.
- 2. There was no mean flight hour between false alarm (MFHBFA) requirement. The MFHBFA value was calculated using a Boeing developed formula based on a false alarm percentage of 45%, and predicted levels of reliability. The result was a MFHBFA goal of 7.4.



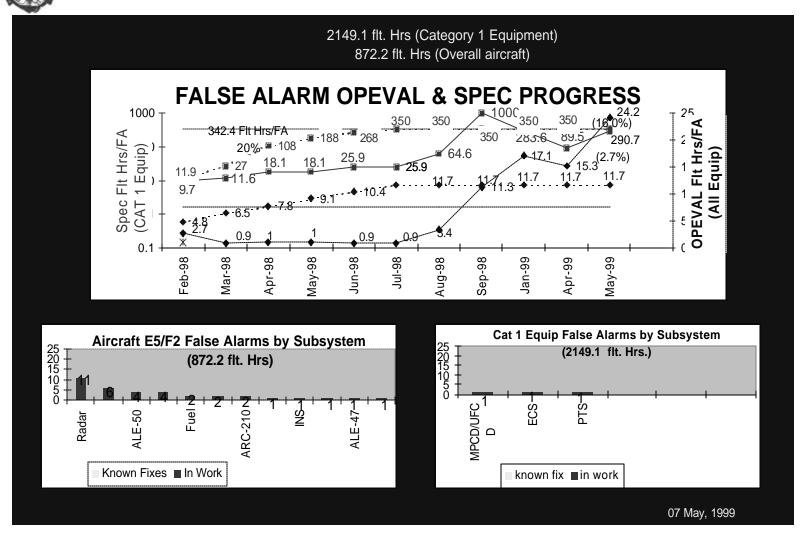
#### F/A-18 E/F BIT False Alarm Status (Flight Test Cum.) RMRB 40 3372 flt. hrs





## F/A-18 E/F BIT False Alarm Status RMRB53 (TECHEVAL)







## F/A-18E/F System Level BIT Status Report



Overall A/C

Cat 1 (E/F)

E/F Unique

C/D Common

Built in Test Flight Test Performance Table (TECHEVAL) 12 Jan. 1998 through 25 September 1998 Overall Aircraft BIT Performance (E5 and F2) 485 flight hours and 385 flights Category 1 CFE BIT Performance (E1, E2, E3, E5, F1 and F2) 1210.6 flight hours and 845 flights

	Fault Detect %		Fault Isolate %		False Alarms			
						Percent		MFHBFA (hrs.)
Category/System	req	current status	req	Current status	req	current status	goal	Curren status
Overall Aircraft	65	113/114=99.1%	85	112/113=99.1%	45	43/156=27.6%	10.0	11.3
Category 1A CFE	90	78/78=100%	95	78/78=100%	20	1/79=1.2%	342.	1210.6
NGC Cat 1A CFE	90	35/35=100%	95	35/35=100%	20	0/35=0%	700.	1210.6
All E/F Modified	na	74/75=98.7%	na	74/74=100%	na	7/81=8.6%	17.3	69.3
All C/D Common	na	38/38=100%	na	38/38=100%	na	36/74=48.7%	24.2	13.5
CAT1 E/F Unique systems								
ECS	95	26/26=100%	95	26/26=100%	5	0/26=0%	na	1210.6
BALD	95	3/3=100%	na	3/3=100%	5	0/3=0%	na	1210.6
Dry Bay Fire	95	None	95	None	5	None	na	1210.6
Eng Ice Det	95	3/3=100%	95	3/3=100%	5	0/3=0%	na	1210.6
Generators	95	8/8=100%	95	8/8=100%	5	0/8=0%	na	1210.6
Strobe Light	95	3/3=100%	95	3/3=100%	5	0/3=0%	na	1210.6
MPCD/UFCD	90	29/29=100%	90	29/29=100%	5	0/29=0%	na	1210.6
EFD	90	9/9=100%	90	9/9=100%	5	1/10=10%	na	1210.6
PTS	95	None	95	None	5	None	na	1210.6
E/F Unique systems								
Fuel	na	5/5=100%	na	5/5=100%	na	1/6=16.7%	na	485.0
Flight Controls	na	15/15=100%	na	15/15=100%	na	3/18=16.7%	na	161.7
SDC	na	1/2=50%	na	1/1=100%	na	0/1=0%	na	485.0
ALE-50	na	2/2=100%	na	2/2=100%	na	0/2=0%	na	485.0
Strain Gages	na	None	na	None	na	None	na	485.0
Pitot	na	None	na	None	na	None	na	485.0
Hydraulics	na	1/1=100%	na	1/1=100%	na	0/1=0%	na	485.0
Propulsion	92	8/8=100%	70	8/8=100%	5	3/11=27.3%	na	161.7
C/D Common systems								
Radar	na	2/2=100%	na	2/2=100%	na	5/7=71.4%	na	97.0
DMS	na	None	na	None	na	None	na	485.0
ALE -47	na	None	na	None	na	5/5=100%	na	97.0
SMS	na	5/5=100%	na	5/5=100%	na	0/5=0%	na	485.0
ALR-67	na	5/5=100%	na	5/5=100%	na	21/26=80.8%	na	23.1
FLIR	na	2/2=100%	na	2/2=100%	na	3/5=60%	na	161.7
AWW13	na	2/2=100%	na	2/2=100%	na	0/2=0%	na	485.0
HARM	na	1/1=100%	na	1/1=100%	na	2/3=66.7%	na	242.5
All other Hydromec systems	na	16/16=100%	na	16/16=100%	na	None	na	485.0
All other Avionic systems	na	5/5=100%	na	5/5=100%	na	None	na	485.0